Support of Forest Inventory Data Collection by Citizen Scientists

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DLR

Background and Motivation

- Precise forest inventory data requested (scientists, politicians, administrators, forest owners, or the forest industry)
- Forest stem volume (or GSV) of great interest
- For GSV: DBH, tree height, the number of trees, species/forest stand specific form factor
- Problem: Such data is very expensive → sample based strategies with large repeat time between two inventories are common
- There exists a great interest to minimize both, effort and inventory errors!

https://www.waldwissen.net (2018/08/29)

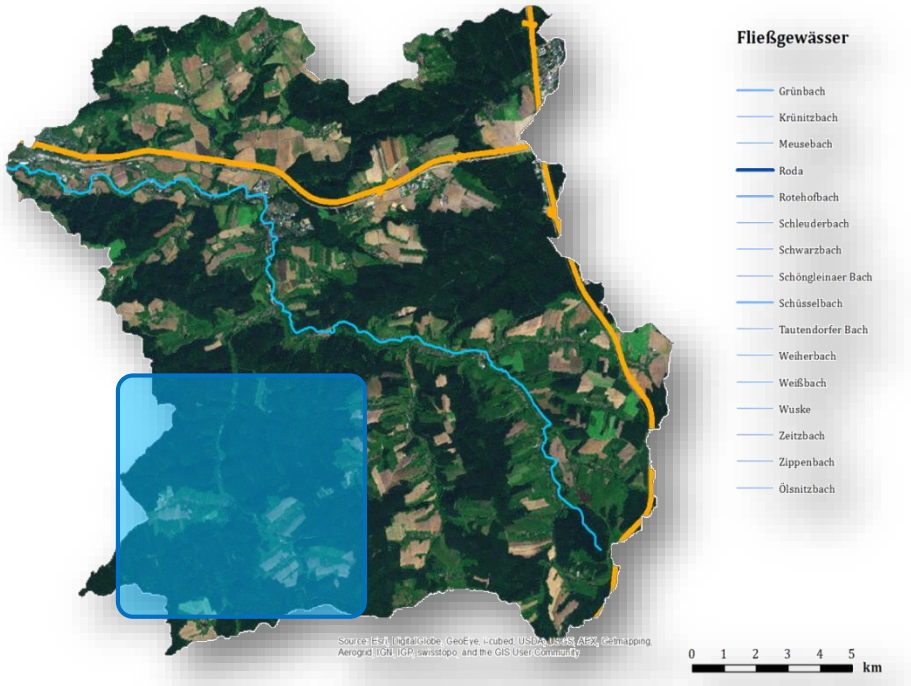
Background and Motivation

- Precise inventory data of particular interest in the research domain: e.g. satellite based methods aiming at GSV estimation suffer from inaccurate reference measurements
- LiDAR: utilized to detect single trees and tree heights (in some Scandinavian countries inventories supported by LiDAR by default)
- Most European countries execute regular and country-wide LiDAR acquisitions
- Instead of LiDAR UAV/SfM based point clouds can be used
- BUT: stem diameter cannot be measured using airborne LiDAR or UAV/SfM data → currently the most efficient approach is manual DBH measurement
- Simplicity of DBH measurements makes this task an excellent citizen science exercise!

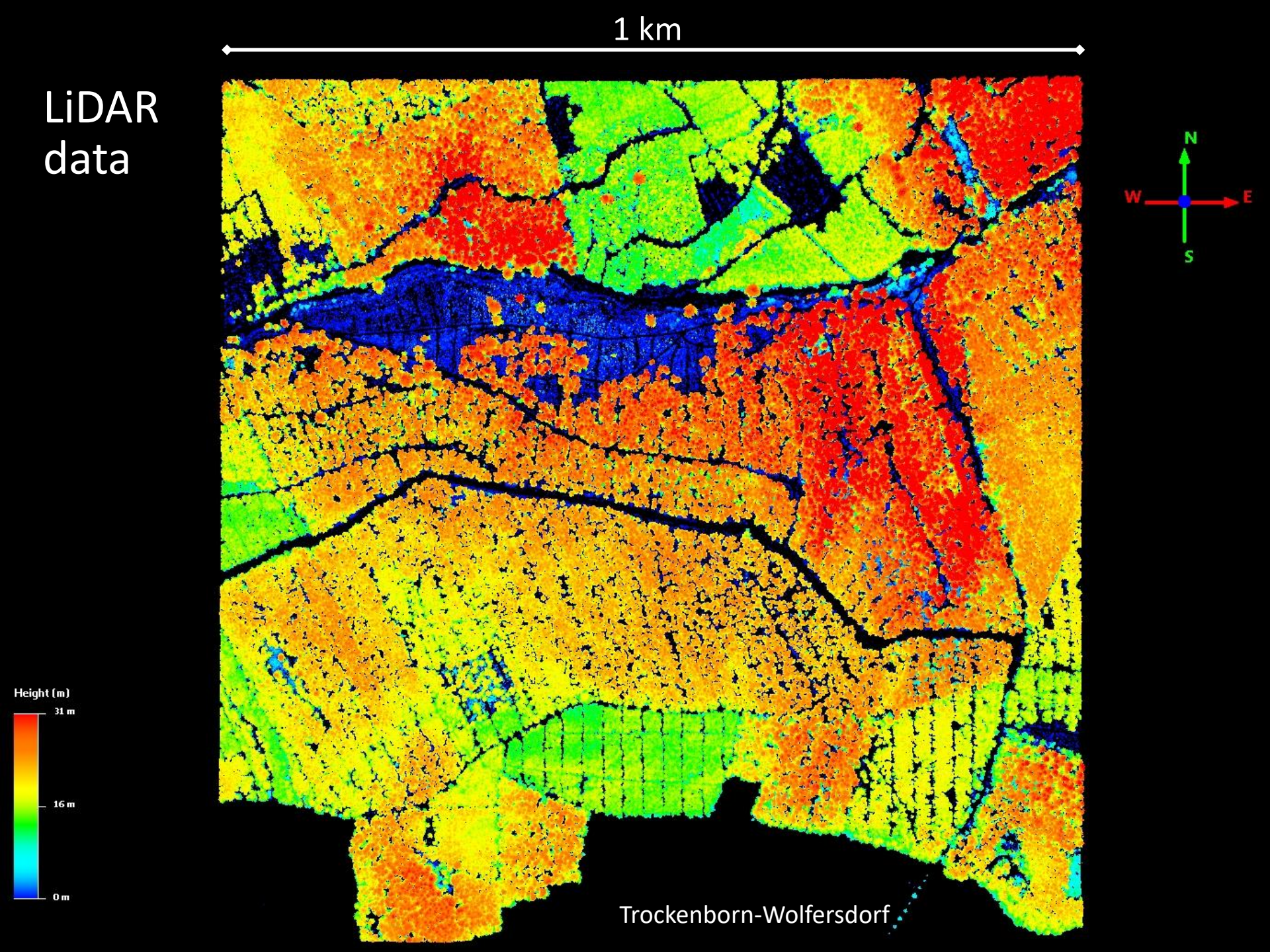
Roda-Supersite

River Catchment Roda

- Roda: tributary of Saale river
- ca. 20 x 20 km²
- ca. 50% forest cover (pine, spruce)



LiDAR data



UAV Equipment

Logo-Team X8000

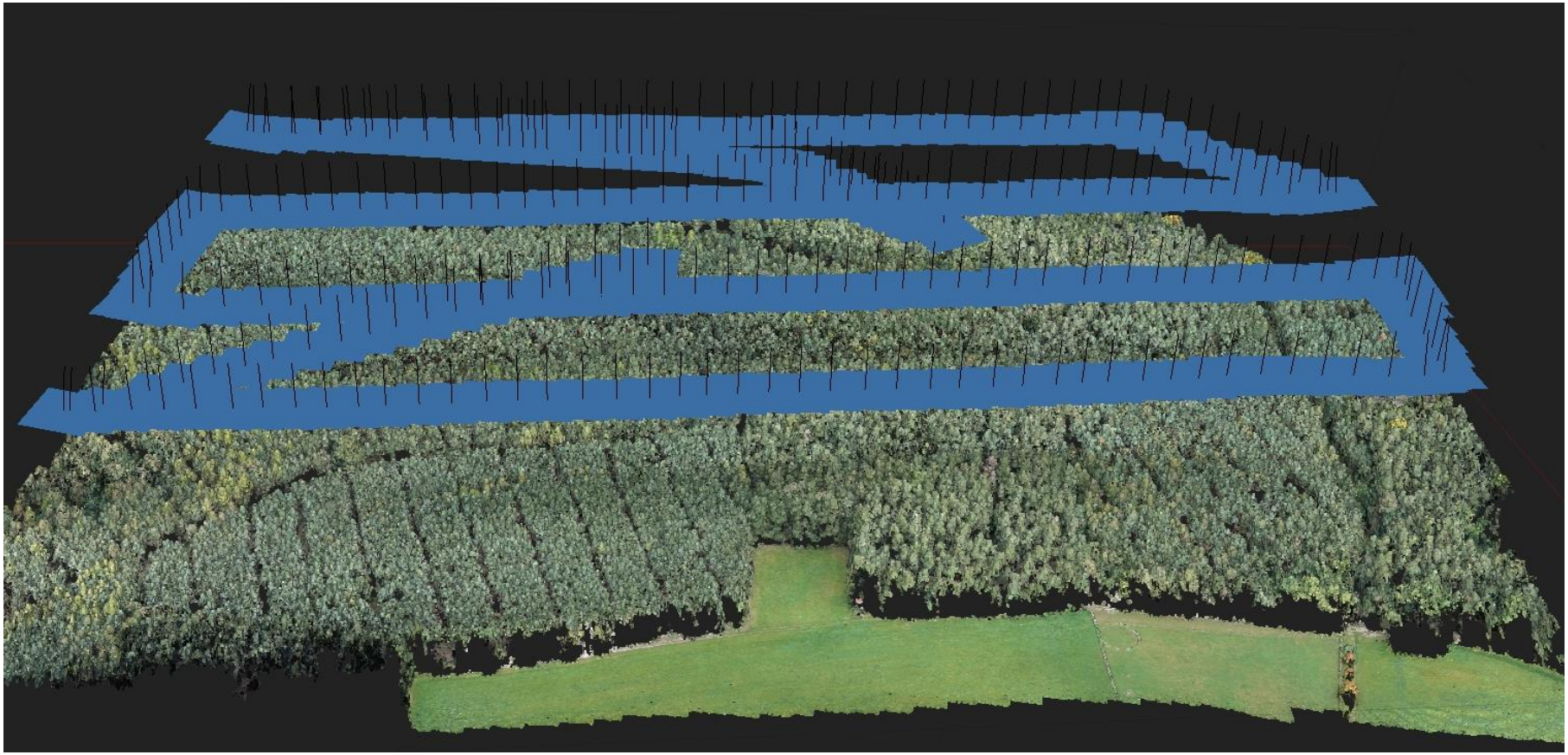
Tetracam Mini-MCA 2

Sony NEX-7

Setup

- Test area subdivided into seven sectors
- Size of sectors ca. 500 m x 500 m
- Flight altitude: 100 m above tree tops
- Horizontal speed: 8 m/s
- Sony NEX-7: focal length 19 mm, exposure time1/400s, ISO200
- Ca. 250 images per sector (80% image overlap)
- Teflon targets for DGPS based georeferencing
- Campaigns: September 2014 und July 2015

UAV campaign setup and image data



Sony NEX-7 (Sector 1)

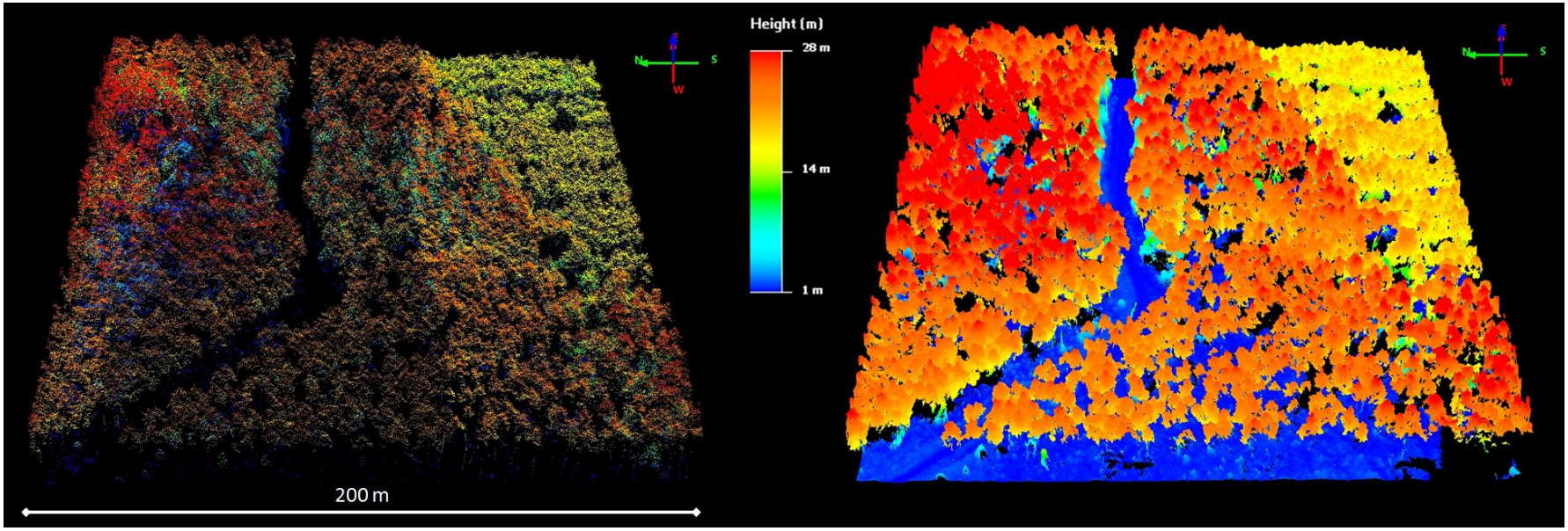
Delineation of pointclouds

Example: Dense point cloud based on sony NEX-7 data

LiDAR vs. UAV

LiDAR

UAV



LIDAR DATA

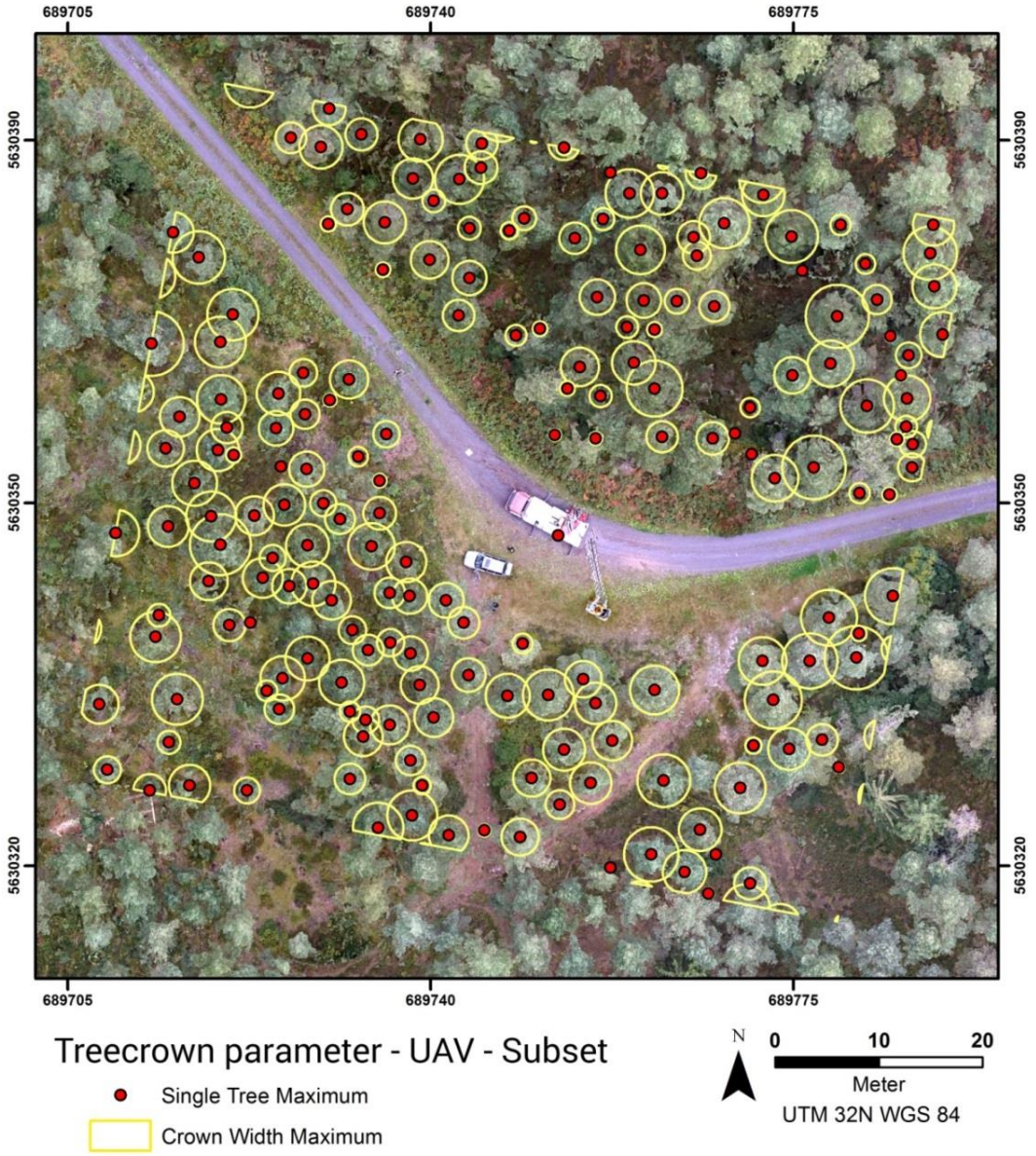
- Acquisition date: 15th February 2014
- Instrument: Optech ALTM Gemini
- Point density: 4-8 points/m²
- Footprint diameter: 0.15 – 0.25 m
- Height RMS: < 0.08 cm
- Points classes: ground & non-ground, each subdivided into first, last, only

UAV POINT DATA

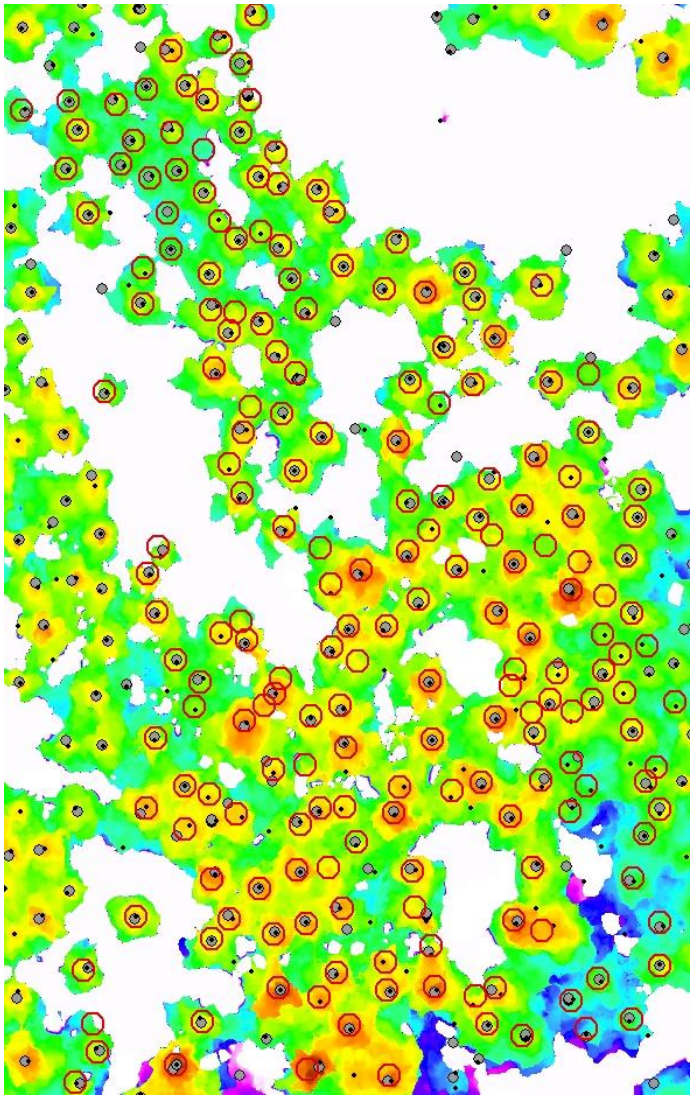
- Delineated from overlapping images using structure from motion (SfM)
- Point density: 310 points/m²
- Georeferencing: DGPS
- Acquisition date: 09th September 2014
- Instruments: Sony NEX-7
- Flight altitude: 100 m over treetops

Automated tree detection

Tree detection using CHM



Automated tree detection



Automatic detection of single trees using nDSM

- Localmax approach with variable window size
- Window size depends on crown height

LiDAR-Tree •

UAV-Tree ○

TLS-Tree ○

LiDAR

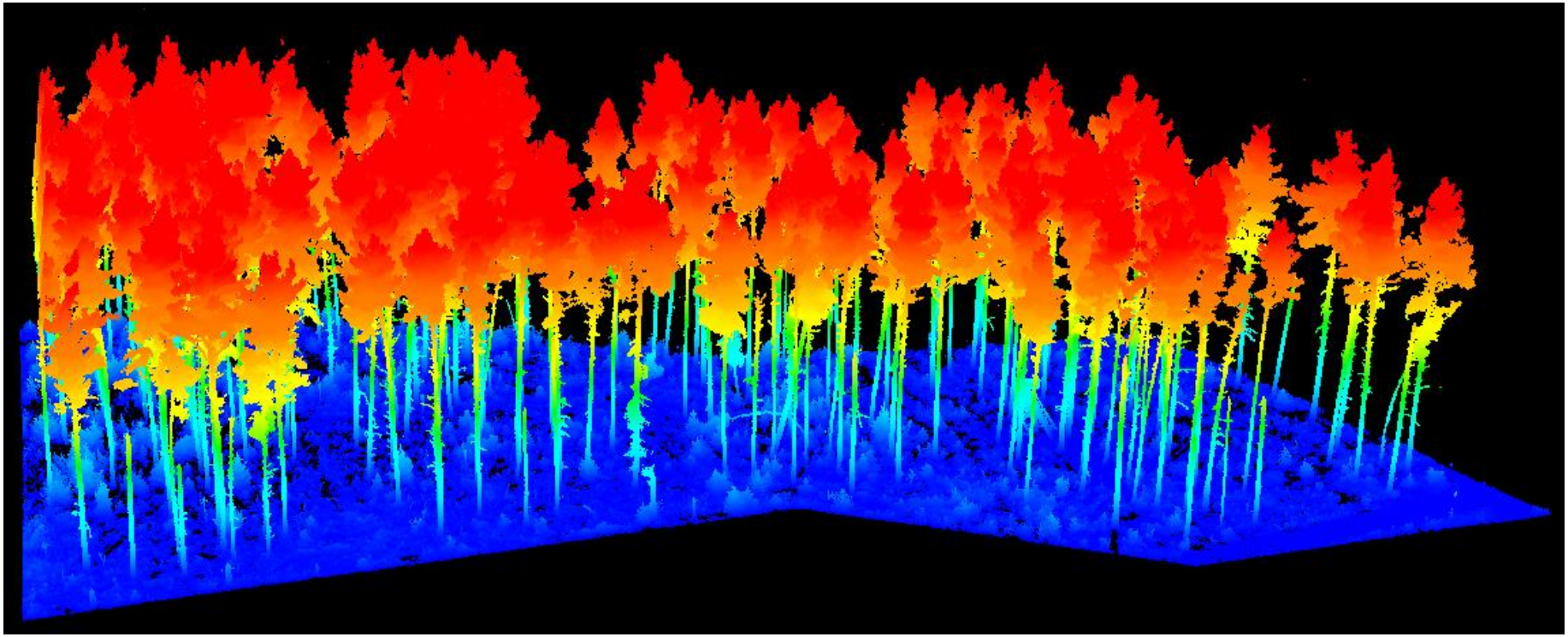
Detection:	78,0%
Commission:	9,8%

UAV

Detection:	93,2%
Commission:	10,7%

The Experiment

TLS Data (Reference)



Acquisition date	9 September 2014
Instrument	Riegl VZ 1000
Area	220 m × 165 m
Number of scan positions	Nine (one horizontal and one vertical scan per position)
Angular resolution	0.02° and 0.04°
Number of points	432,026,502
Positional uncertainty of single scans (relative)	0.005–0.016 m (1 sigma)
Positional uncertainty of single scans (absolute)	2.5 cm (1 sigma), precision better than 1.0 cm

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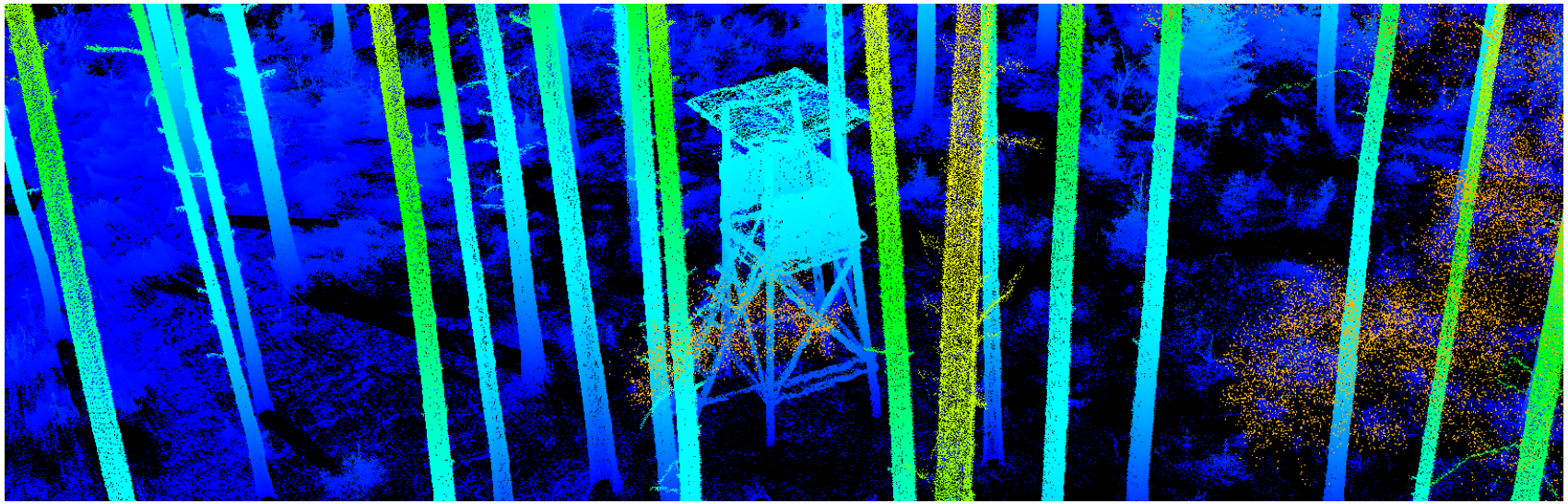
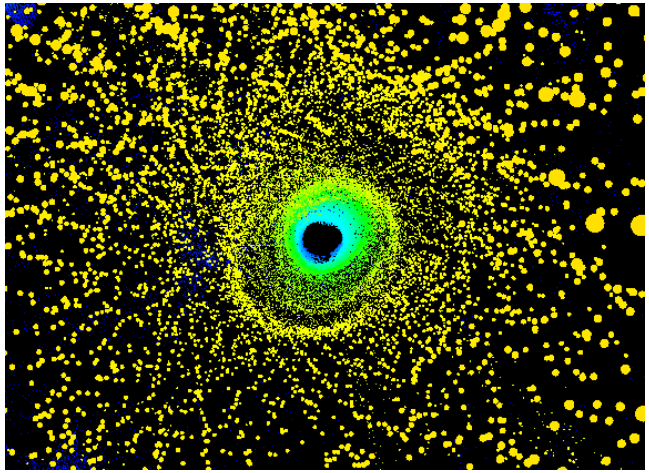
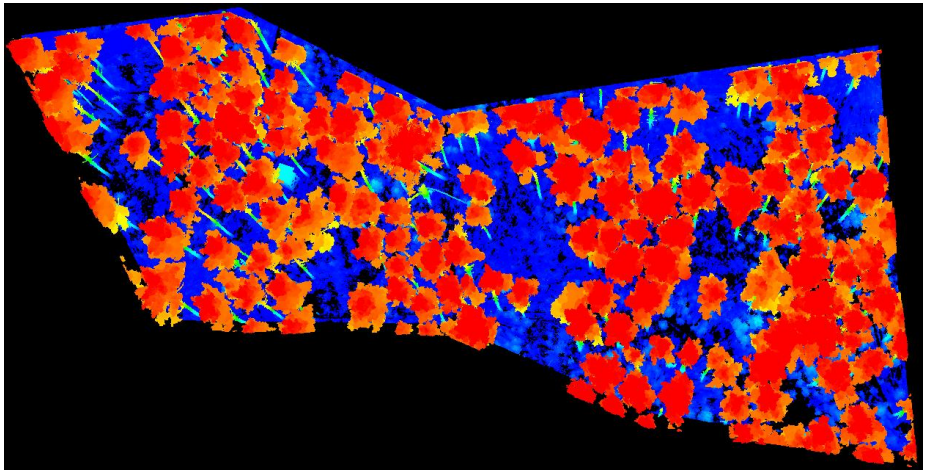
TLS Data (Reference)





„Inside“ a stem

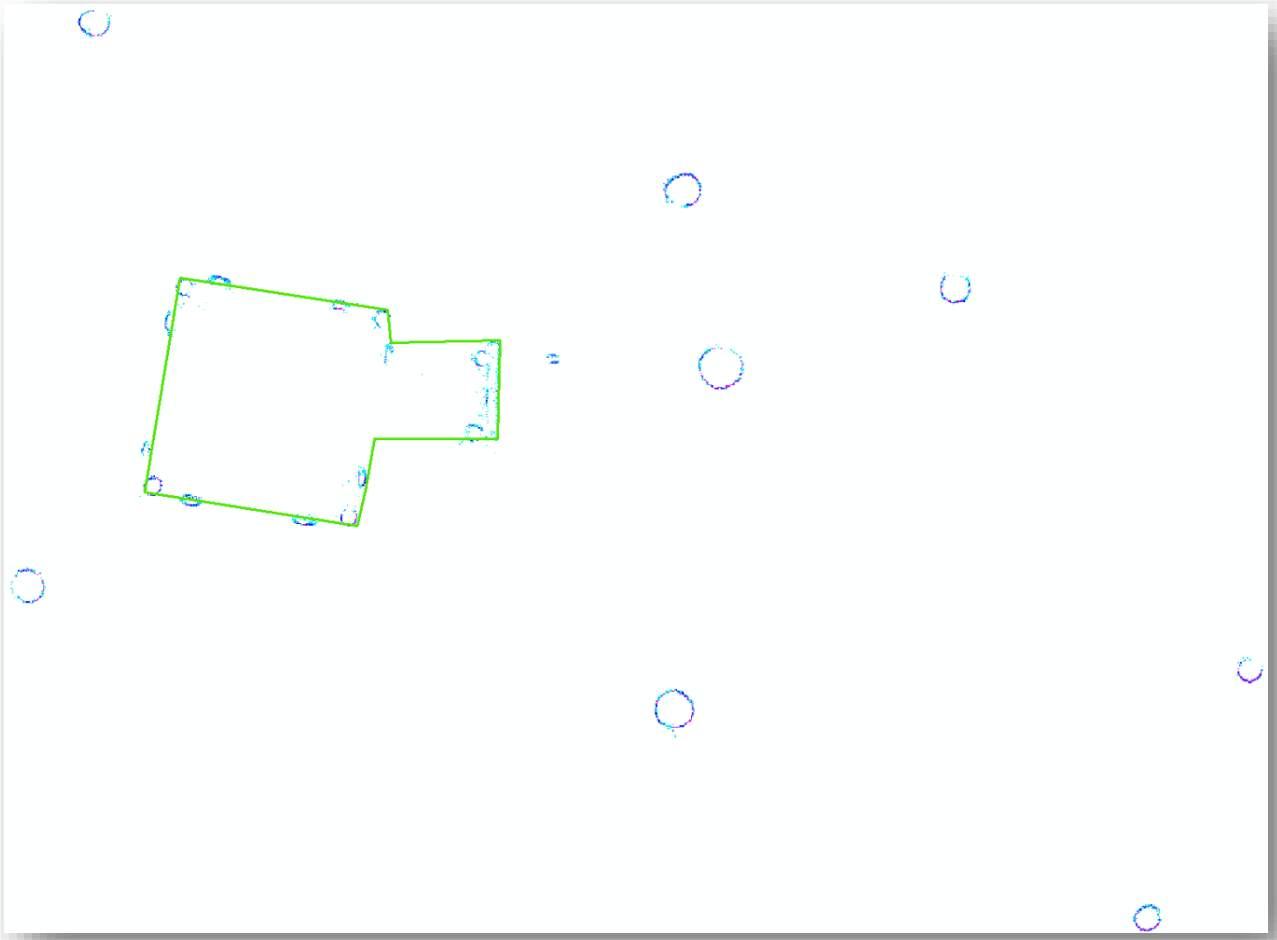


Top down overview

TLS Data

TLS based tree positions

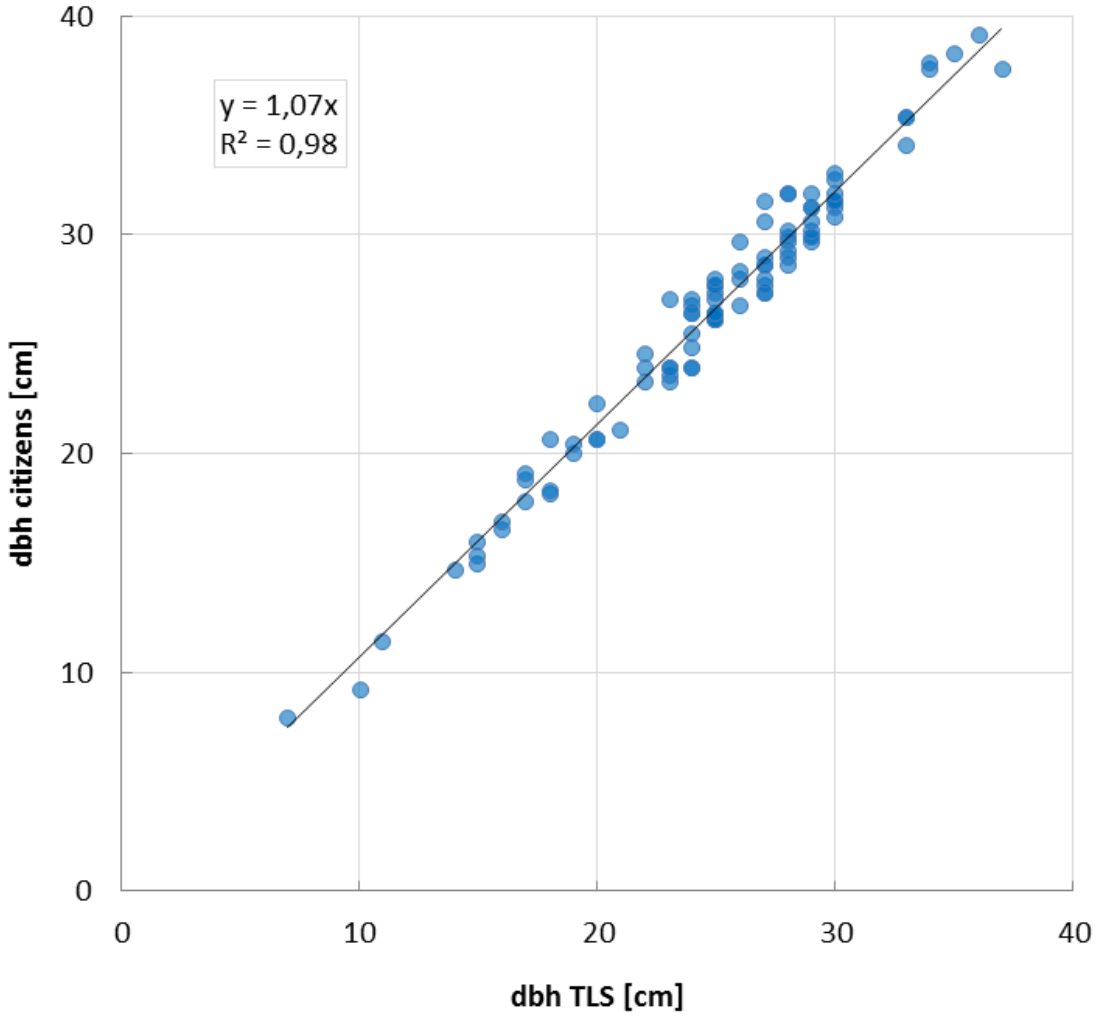
TLS Data



TLS based estimation of DBH

Citizen Science field campaign (Montessori School Jena)

Citizen Science field campaign: Results



Summary and Conclusions

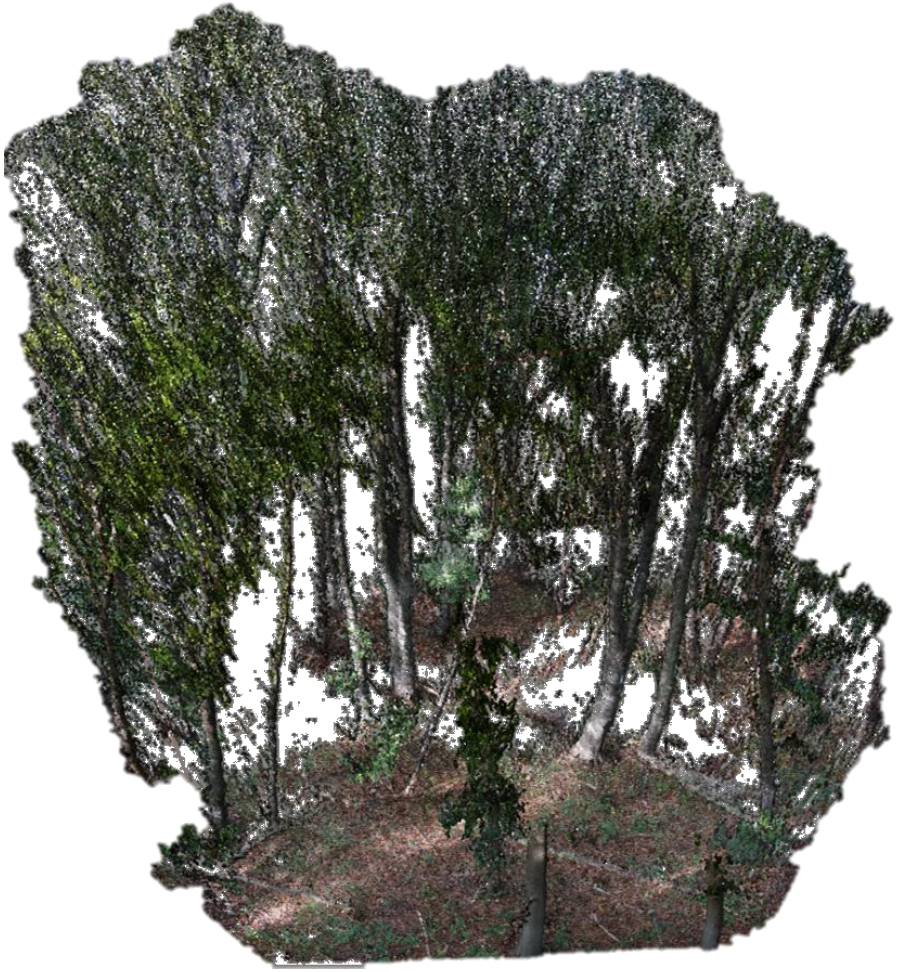
- DBH of 102 trees was measured, DBH varied between 7 cm and 38 cm
- Great agreement ($R^2 = 0.98$) between TLS and student campaign based measurements
- Identification of correct tree during campaign challenging (orientation difficulties and a weak GPS signal underneath forest canopy) → critical issue (ease of campaigns, data quality, motivation etc.)
- Data acquisition strategy with support of citizens turned out being accurate enough, however, higher grade methods can provide more data (Outlook)

Outlook – Data acquisition

SfM related methodology development using ground based image data

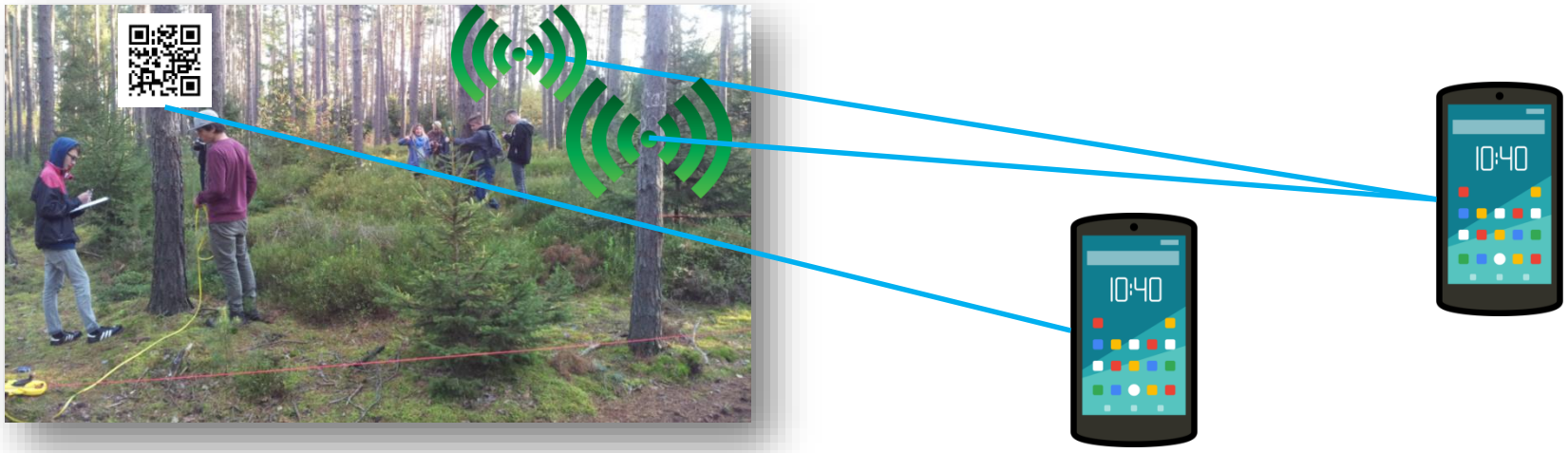
Image data gathered by citizens

http://www.dtb-online.de/portal/gymwelt/natursport/crossscouting.html



Point cloud of a beech forest derived from ground based photographs using low-cost off-the-shelf equipment (Sony NEX-7)

Outlook – Positioning



GOAL

- Exact localization without expensive hard- and software under poor GNSS signal conditions

TECHNIQUES

- Using raw signal data of GPS, Glonas, Galileo (from Android 7)
- Off-set correction using reference positions (Quasi-DGPS)
- Incorporation of bluetooth beacons for navigation and positioning
- GNSS + kinematic sensors (accelerometer, gyroscope, magnetic sensor)

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